AP BIOLOGY · UNIT 8 · TOPIC 8.7

Disruptions in Ecosystems

Learning objective 8.7.A Explain the interaction between the environment and random or preexisting variations in populations, 8.7.B explain how invasive species affect ecosystem dynamics, 8.7.C describe human activities that lead to changes in ecosystem structure and dynamics, and 8.7.D explain how geological and meteorological activity leads to changes in ecosystem structure and dynamics.

Name: Date: Period:

Use the tool **What Changes, and How Fast**. Parts 1 and 2 use **Already there**, Part 3 uses **Nobody ordered it**, Part 4 uses **Free of what ate it**, Parts 5 and 6 use **What we put in**, and Part 7 uses **How fast**. This topic brings together an argument the whole course has made: when an environment changes, the variation already present in a population determines which individuals survive. Four of these Parts depend on a detail of **order or timing** rather than on a definition, so read the step numbers as carefully as the values.

Part 1 · Four populations, one destination

Three genotypes: `w(AA) = 1 – s`, `w(Aa) = 1`, `w(aa) = 1 – t`, with **s = 0.2** and **t = 0.8**. The heterozygote is the fittest genotype. The tool opens on the Already there tab with the result showing. Before you look at the Where all four runs finish readout, write your prediction for each population. Then record where all four runs finish, and calculate t / (s + t).

Starting frequency, p	Your prediction	After 200 generations	t / (s + t)
0.02			
0.25			
0.60			
0.95			

1. (a) Describe an adaptation.

(b) Explain why an adaptation must be described in relation to a particular environment.

2. Describe heterozygote advantage.

3. All four populations in the Part 1 table finished at the same allele frequency from very different starting frequencies. Explain what this result indicates about what determines the equilibrium frequency.

Part 2 · Why the costly allele is not removed

At equilibrium, allele a, whose homozygote aa has a fitness of only 0.2, is at a frequency of **20%**, so **4.0%** of every generation is born aa. The second chart compares this balanced run with a run of plain directional selection and with a run in which the cost to AA is removed. Record each run's value at generation 200: the balanced run stays at its Part 1 value, the tool's verdict gives the directional run's value, and the note What an adaptation is, why the costly allele stays, and who owns the balance gives the third run's value. Use the generations 150–200 readouts to decide whether each run is still changing.

Run	Value at generation 200	Still changing?	Where it is heading
Heterozygote advantage			
Plain directional selection			
Balance, then the pressure on AA removed			

4. Explain why heterozygote advantage keeps allele a in the population, even though aa individuals have low fitness.

5. In the directional run, p has not reached 1 after 200 generations and does not pass 0.99 until generation 352. Explain why removing the last few percent of a disfavored recessive allele is so slow.

6. (a) Describe the effect on the allele frequencies of removing the cost to the AA homozygote.

(b) Explain what this result indicates about the role of the environment in maintaining the polymorphism.

Part 3 · Two hypotheses, one measurement

Many identical cultures are grown from single cells, then each is exposed to something that kills all but the resistant. Under one hypothesis the resistance appears **because of** the exposure; under the other it was already there. Both are set to produce the same expected number of survivors, **4.61** per culture, so no average can separate them. Record the other values from the table on the Nobody ordered it tab.

Hypothesis	Expected	Observed mean	Variance ÷ mean	Largest culture	Cultures with none
Mutations arise on demand	4.61				
Mutations arise beforehand	4.61				

7. Describe what it means to say that mutations are not directed by specific environmental pressures.

8. Both hypotheses predict the same mean number of survivors per culture.
(a) Using the Part 3 table, describe a measurement that distinguishes the two hypotheses.

(b) Explain why the two hypotheses predict different results for this measurement.

9. The last column of the Part 3 table, Cultures with none, gives a test that needs no statistics.
(a) Describe the difference between the two hypotheses in the number of cultures with no resistant cells.

(b) Explain why the hypothesis that mutations arise beforehand predicts many cultures with none.

Part 4 · An invader that is worse at everything

The introduced species grows more slowly than the native (**0.24** against **0.3**) and tolerates less crowding (**800** against **1,000**). Write your prediction for each run before you open the Free of what ate it tab. Then click Native's predator present and Nothing eats either in turn. The only difference between the runs is whether the native still has its own predator.

Scenario	Your prediction	Native ends at	Invader ends at	Who wins
Native's predator present				
Nothing eats either species				

10. Explain how an introduced species can become invasive in a new ecosystem.

11. The invader in Part 4 grows more slowly than the native and tolerates less crowding, yet in one run it reached 773 while the native fell to 28. Explain what this result indicates about what makes a species invasive.

Part 5 · Biomagnification

A consumer must eat about ten units of prey to build one unit of itself, so only **10%** of the energy passes up a level. Record the share of the original energy and the toxin concentration for each level from the tool's table. Then calculate × the water (the toxin concentration divided by the 0.05 ppm in the water), and multiply the share, written as a decimal, by that factor in the last column.

Level	Share of the original energy	Toxin, ppm	× the water	Share × factor
Producers				
Primary consumers				
Secondary consumers				
Tertiary consumers				
Top consumers				

12. (a) Describe biomagnification.

(b) Explain why the last column of the Part 5 table is 1 at every level.

13. Explain why a persistent toxin becomes more concentrated up a food chain while the energy decreases.

14. The water in this example contains 0.05 ppm of the toxin, a concentration low enough to be considered safe. Explain why the top consumers, the organisms furthest from the water, are most at risk.

Part 6 · Eutrophication

Nutrients arrive for the first 20 steps only, then stop. Click each nutrient input in turn and record the **step numbers** as carefully as the values, because the order of events is the point of this Part.

Nutrient input	Algae peak at step	Oxygen lowest at step	Lowest oxygen	Fish left
2.0				
8.0				
20.0				
40.0				
60.0				

15. Explain what causes the death of the fish in a lake affected by eutrophication.

16. In the Part 6 table, the oxygen minimum comes 43 to 47 steps after the algal peak.
(a) Describe the effect of the living algae on the oxygen in the water.

(b) Explain why the oxygen minimum comes after the algal peak rather than during it.

17. In the Part 6 table, all of the fish survived at every nutrient input except 60.0.
(a) Explain why a small amount of nutrient enrichment does not kill the fish.

(b) Describe what this result indicates about whether nutrients are harmful to a lake.

Part 7 · How fast

Every disruption the CED names for this topic, ordered by how long it takes. Record each row from the tool’s table. The durations are approximate and heavily rounded, because the sources support no more than that.

Disruption	CED objective	Kind	Years, approximate (the tool’s Order of magnitude column)
Meteor impact on dinosaurs			
El Nino			
Logging			
Potato blight			
Zebra mussels			
Dutch elm disease			
Kudzu			
Urbanization			
Monocropping			
Global climate change			
Continental drift			

18. The durations in the Part 7 table span 8 orders of magnitude. Explain why the speed of an environmental change matters as much as its size.

19. Describe the mechanism that all seven Parts of this handout have in common.

What the model simplifies

The selection recursion assumes an infinite population, random mating, discrete non-overlapping generations, no mutation, no migration and constant fitnesses. Every one of those is false of real populations, and the first matters most: in a small population an allele at 20% can be lost to drift regardless of what selection would prefer.

The heterozygote-advantage example is the shape of the sickle-cell case rather than a model of it. The real system involves several alleles, several malaria parasites, and a fitness landscape that shifts with the local burden of infection.

The mutation experiment uses a deterministic generator seeded to a fixed value, so the numbers are identical on every load and can be verified. Real cultures vary; the qualitative pattern (a few jackpots, many empties, variance far above the mean) is the robust part, and it is what Luria and Delbrück found in 1943.

The two hypotheses are deliberately given the same expected number of resistant cells, so that no average can separate them in principle. Their sample means still differ substantially, which is not a flaw in the simulation: the undirected distribution's weight sits in rare jackpots, so an average of 200 cultures lands well below its own expectation. An average is a poor summary of a distribution shaped like that, which is exactly why the original experiment compared variances.

The invasion model gives the native a predator and the invader none, and holds everything else fixed. Real invasions usually involve several advantages at once (escape from predators, escape from pathogens, disturbance that favors fast colonizers), and what is isolated here is that the first of those is sufficient on its own, not that it is the only one operating.

Biomagnification uses a single transfer efficiency of 10% at every step. Real efficiencies range from about 2% to 40% and vary by ecosystem, and real toxins are excreted at some rate rather than not at all. The structural claim is what is asserted: the share of the original energy multiplied by the concentration factor is exactly 1 at every level.

The eutrophication model is a compartment sketch, not a limnological simulation. An earlier version fed nutrients in continuously and the oxygen minimum then arrived at the same moment as the algal peak, which would have hidden the one thing the section exists to show. The nutrients now arrive as a pulse, as a runoff event actually does, and the oxygen minimum falls 43 to 47 steps after the bloom.

The durations in the last part are cited magnitudes drawn from the literature rather than outputs of a model, and they are heavily rounded. What is computed is the comparison between them.

One oddity is the CED's, not this tool's: logging, urbanization and monocropping are listed in the 2025 Course Framework under 8.7.D, the objective about geological and meteorological activity, rather than under 8.7.C, the objective about human activities. That is where the CED puts them, so that is where they appear here, labeled as human. It is worth telling students, because an exam question could reasonably reference either objective.